RESEARCH

Laboratory evaluation of amalgam separators

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Waste amalgam particles are generated during the placement and removal of amalgam restorations in the dental office. Some of these particles end up in dental office wastewater. Although chairside traps and vacuum filters remove some particles from the wastewater stream, particles that remain in the wastewater can settle along the waste pipe or be discharged into the sewer.

A study based on wastewater samples taken at the connection to the sewer reported that dentists discharge an average of 35 milligrams of mercury (as amalgam) into the sewer per day.[1] This study and other studies, using wastewater samples collected close to the dental unit or vacuum pump, estimated that dental offices could contribute from 8 to 14 percent of the total mercury load to wastewater treatment plants.[2,3]

The results show that all 12 amalgam separators exceeded the International Organization for Standardization requirement of 95 percent amalgam removal efficiency.

While there is no information on how much amalgam in dental office wastewater actually reaches wastewater treatment plants, and even though no mercury was detected when amalgam particles were subjected to simulated wastewater treatment processes,[4] there is a growing impetus across the United States to decrease the amount of amalgam in dental office wastewater that is discharged to sewers. This has resulted from national, state and local initiatives to decrease or virtually eliminate the discharge of mercury and mercury-containing items into the environment.[5,6] In addition, wastewater treatment plants are facing discharge permits that have lower mercury concentration limits than those in the recent past.

As a result, wastewater treatment agencies in several regions are looking to reduce mercury and mercury-

ABSTRACT

Background. Amalgam in dental wastewater is receiving increasing scrutiny from regulators because of national, state and local initiatives to reduce or virtually eliminate the discharge of mercury and mercury-containing items into the environment. Amalgam separators are considered to be one means of reducing the amount of amalgam that dental offices discharge into sewers. The purpose of this study was to evaluate the amalgam removal efficiency of commercially available amalgam separators and the total mercury concentration in the effluent from laboratory testing.

Methods. The authors evaluated the amalgam removal efficiency of 12 amalgam separators according to International Organization for Standardization, or ISO, Standard 11143 for Amalgam Separators. Total mercury concentration in the effluent was calculated using the mass of amalgam particles larger than 1.2 micrometers and the volume of effluent, together with U.S. Environmental Protection Agency, or EPA, Method 245.1 for amalgam particles smaller than 1.2 µm. Total dissolved mercury also was determined.

Results. The results show that all 12 amalgam separators exceeded the ISO 11143 requirement of 95 percent amalgam removal efficiency. Statistical differences were found in the efficiencies of the separators. Both the total mercury concentration and total dissolved mercury concentration in the effluent demonstrated large variations.

Conclusions and Clinical Implications. This laboratory evaluation shows that amalgam separators removed at least 96.09 percent of the amalgam in samples with particle-size distribution as specified in ISO 11143. Total mercury concentration and total dissolved mercury concentration in the effluent varied widely for each amalgam separator. Additional research is needed to develop test methods to evaluate the efficiency of amalgam separators in removing small amalgam particles, colloidal amalgam particles and ionic mercury in solution.

containing waste at the sources of discharge. Dental offices are identifiable sources because of the waste amalgam particles that are discharged in wastewater. Amalgam separators were developed with the aim of reducing the amount of amalgam in dental office wastewater that is discharged into sewers.

Amalgam separators use one or multiple technologies to remove amalgam from dental office wastewater. These technologies include sedimentation, filtration, centrifugation and ion exchange. The performance of amalgam separators, especially in regard to their efficiency in removing amalgam from wastewater, is of interest to dentists, regulators and wastewater agencies. Recognizing the need to obtain additional information about amalgam separator performance, we conducted a laboratory evaluation to determine the amalgam removal efficiency of these devices and the total mercury concentration in their effluent.

Amalgam separators use one or multiple technologies to remove amalgam from dental office wastewater.

MATERIALS AND METHODS

For this laboratory evaluation, we obtained from manufacturers or distributors 12 amalgam separators that are commercially available in the United States. Table 1 presents information about each of these amalgam separators, including the technologies they use to remove amalgam, product information provided by the manufacturers and the manufacturers' suggested retail prices as of January 2002 (also see sidebar on page 585).

We used three laboratory evaluation methods to determine the following for each amalgam separator:

- amalgam removal efficiency;
- total mercury concentration in the effluent from the laboratory testing;
- total dissolved mercury concentration in the amalgam separator effluent. (The U.S. Environmental Protection Agency, or EPA, considers all mercury that passes through 0.45-micrometer filters to be dissolved mercury.)

Amalgam removal efficiency. International Organization for Standardization, or ISO, Standard 11143 for Amalgam Separators was used to evaluate the amalgam removal efficiency of the 12 separators.[7] The ISO standard requires that the amalgam separator remove at least 95 percent of the amalgam when the separator is subjected to the test method specified in the standard. Using the ISO standard, we evaluated one representative sample of each amalgam separator. The figure (page 580) shows a schematic of the ISO test arrangement.

Before the evaluation, staff members from the ADA laboratory flushed the amalgam separators with filtered tap water. The ISO test for amalgam removal efficiency uses 10.00 grams of amalgam particles that are composed of three portions of different sizes: 60 percent of the particles are 3.15 millimeters or smaller and larger than 0.5 mm; 10 percent of the particles are 0.5 mm or smaller and larger than 0.1 mm; and 30 percent of the particles are 0.1 mm or smaller, with particle-size distribution specified in the ISO standard.

We determined the sample weight and made a slurry composed of the amalgam particles and 1 liter of filtered (1-µm nominal pore size) water containing 1 g of sodium pyrophosphate. Within minutes of mixing, the slurry is stirred and then poured into the amalgam separator, along with filtered (1-µm nominal pore size) tap water to achieve the maximum flow rate specified by the manufacturer of the amalgam separator. The effluent water from the amalgam separator is collected in a vessel.

The collected effluent water, containing amalgam particles not retained by the amalgam separator, is filtered through a series of three preweighed filters with nominal pore sizes of 12 µm, 3 µm and 1.2 µm. The filters, with the amalgam particles collected on them, are dried to constant weight in a desiccator at room temperature. We weighed the filters using a balance (Mettler AE 163, Mettler Toledo, Columbus, Ohio), which is accurate to 0.0001 g. We used the amount of amalgam retained by the filters to calculate the efficiency of each separator according to this formula:

$$\text{Percent Efficiency} = 100 \times [1 - (\text{weight of amalgam on filters})/(\text{weight of sample})]$$

ISO 11143 requires that amalgam separators be tested both empty and full. The full condition means that the amalgam separator is filled to its stated capacity with a combination of glass beads (1-mm diameter) (70 percent of the capacity) and

TABLE 1

AMALGAM SEPARATORS EVALUATED.

AMALGAM SEPARATOR	SERIAL NUMBER	MANUFACTURER/ DISTRIBUTOR	REMOVAL TECHNOLOGY	MANUFACTURER'S SUGGESTED RETAIL PRICE*
A1000	30324	Air Techniques Inc. 70 Cantiague Rock Road Hicksville, N.Y. 11801 1-800-AIR-TECH	Sedimentation	$750
Amalgam Collector	NA†	R&D Services 8120 Green Lake Drive N. Seattle, Wash. 98103 1-206-525-4995	Sedimentation	$350
Asdex	NA	Avprox Inc. 2001 4th St. N. Suite C St. Petersburg, Fla. 33704 1-800-300-1249	Filtration	$215
BullfroHg	B0118	DRNA Dental Recycling North America Inc. P.O. Box 1069 Hackensack, N.J. 07601 1-800-360-1001	Sedimentation/ filtration	Lease $100 per month
Durr 7800/ 7801	NA	Air Techniques Inc.	Centrifugation	$4,000
ECO II (Economy System Type II)	EC00131	Metasys 5001 S.W. 74th Court Suite 206 Miami, Fla. 33155 1-305-807-6303	Sedimentation	Lease $29 per month
Hg5	HG5-B-0038	SolmeteX Inc. 50 Bearfoot Road, Suite 2 Northborough, Mass. 01532 1-508-393-5115	Sedimentation/ filtration/ion exchange	$500
Hg10	NA	SolmeteX Inc.	Sedimentation/ filtration/ion exchange	$6,000
MRU (The Mercury Recovery Unit)	NA	DRNA Dental Recycling North America Inc.	Sedimentation/ filtration/ion exchange	Lease $150 per month
MSS 2000	SU0100-A213	Maximum Separation Systems Inc. #100B-1779 Sean Heights Sannichton, British Columbia V9A 2B4 Canada 1-800-799-7147 or 1-250-652-5279	Sedimentation/ filtration	$3,000
Rasch 890-4000	19171	AB Dental Trends Inc. 211 Grover St. Lynden, Wash. 98264 1-360-354-4722	Sedimentation/ filtration/ion exchange	$1,650
RME 2000	J200085	Rebec 18921 Dellwood Drive Edmonds, Wash. 98026 1-800-569-1088	Sedimentation	$1,895

* Information accurate as of January 2002.
† NA: Not applicable.

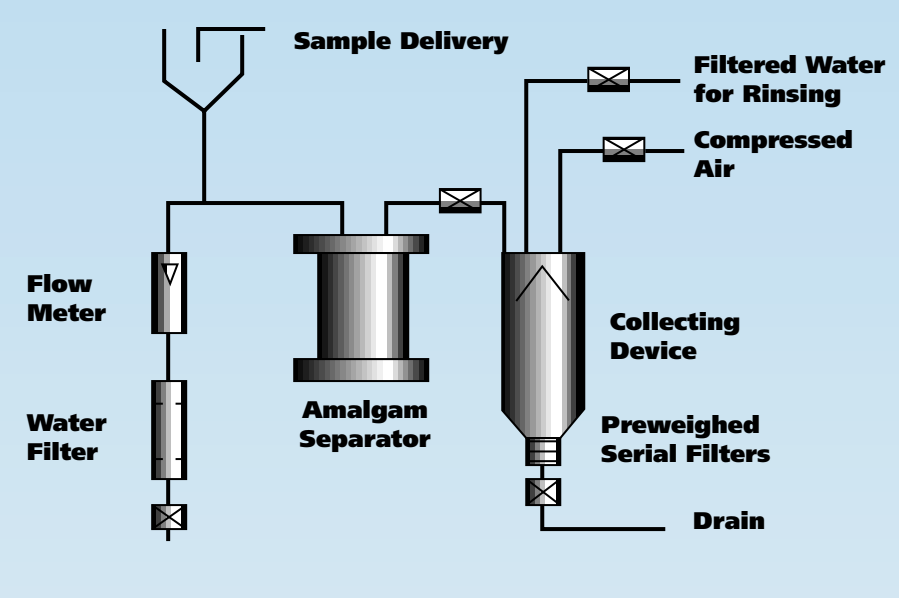

Figure. Schematic of the International Organization for Standardization test arrangement.

amalgam scrap (maximum particle size, 0.3 mm) (30 percent of the capacity). We tested the empty amalgam separators by first placing no amalgam in the amalgam separator and then conducting two more tests without removing the retained amalgam. For the full testing condition, we filled each amalgam separator as defined by ISO 11143 and tested it for three runs. We calculated the mean efficiency separately for the empty and full amalgam separators. The lower of the two mean values for each amalgam separator is considered to be the ISO test result.

We obtained amalgam samples from the Becker Company (bm becker messtechnik GmbH, Winnenden, Germany), which certified that the samples were in compliance with the particle-size distribution specified in ISO 11143. In addition, we confirmed each amalgam sample's compliance with the ISO 11143 particle-size distribution requirement using the electrozoning (Coulter) method, and tested 11 separators empty and full. One separator (Hg10, SolmeteX Inc., Northborough, Mass.), designed to handle multiple dental units in large dental clinics, was tested empty only because it was impractical to fill it with more than 15 kilograms of amalgam scrap for the full test. For this amalgam separator, the empty test result was used as the ISO test result.

We subjected the amalgam removal efficiencies of the separators to statistical analysis using analysis of variance and multiple comparison (Tukey) tests. For each amalgam separator, the mean efficiencies of the empty device and the full device were compared using the Student *t*-test.

Total mercury concentration in effluent. Because regulators often use the total mercury concentration in wastewater in deciding on wastewater discharge limits and water quality limits, we decided to evaluate the total mercury concentration in the effluent from each amalgam separator test. To do this, we calculated the contributions of mercury from two sources: the amount of amalgam retained in the preweighed filters per volume of the effluent, and the mercury concentration in the filtrate (1.2-µm nominal pore-size filter). The total mercury concentration in the effluent is the sum of these two amounts.

We also measured the volume of effluent that passed through the preweighed filters. To determine the total mercury concentration in the effluent attributed to the amalgam retained in the preweighed filters, we used a mercury-alloy ratio of 1:1 and applied the following equation:

$$\text{Mercury Concentration} = 0.5 \times (\text{weight of amalgam in the preweighed filters})/\text{volume of effluent}$$

To determine the total mercury concentration in the effluent attributed to amalgam in the filtrate (1.2-µm nominal pore-size filter), we took two aliquots of the filtrate for each amalgam separator run and tested them for mercury using the U.S. EPA Method 245.1. EPA Method 245.1 involves acid digestion (sulfuric acid and nitric acid), oxidation (potassium permanganate, potassium persulfate) to mercury ion (Hg^{2+}), reduction (stannous chloride) to elemental mercury (Hg^{0}) and then measurement of mercury using atomic absorption spectrometry. We also tested samples of filtered tap water used in the ISO test.

Total dissolved mercury in effluent. We filtered two aliquots of each filtrate further (nominal pore size, 0.45-µm filter), and analyzed each resultant filtrate (0.45-µm filtrate) for total dissolved mercury using EPA Method 245.1. The

detection limit for mercury was 0.2 parts per billion, or ppb.

RESULTS

Amalgam removal efficiency. The amalgam removal efficiencies of the 12 amalgam separators evaluated were 96.09 percent or greater, exceeding the ISO 11143 requirement of 95 percent. Table 2 presents the results for the amalgam separators tested. The results show statistical differences between amalgam separators. However, no differences were found between the separators in group 1 (that is, Hg10, MRU [DRNA Dental Recycling North America Inc., Hackensack, N.J.], Rasch 890-4000 [AB Dental Trends Inc., Lynden, Wash.], Amalgam Collector [R&D Services, Seattle], RME 2000 [Rebec, Edmonds, Wash.], Hg5 [SolmeteX Inc.] and Asdex [Avprox Inc., St. Petersburg, Fla.]), group 2 (that is, Rasch 890-4000, Amalgam Collector, RME 2000, Hg5, Asdex and MSS 2000 [Maximum Separation Systems Inc., Sean Heights, Sannichton, British Columbia, Canada]) group 3 (that is, Hg5, Asdex, MSS 2000 and BullfroHg [DRNA Dental Recycling North America Inc.]) and group 4 (that is, Durr 7800/7801 [Air Techniques Inc., Hicksville, N.Y.] and ECO II [Metasys, Miami]. The results for A1000 (Air Techniques Inc.) were statistically different from those for the other amalgam separators.

TABLE 2

AMALGAM REMOVAL EFFICIENCY.

AMALGAM SEPARATOR*	MEAN (SD†) EFFICIENCY OF EMPTY SEPARATOR (PERCENTAGE)	MEAN (SD) EFFICIENCY OF FULL SEPARATOR (PERCENTAGE)
A1000	96.09 (0.39)	96.34 (0.46)
Amalgam Collector	99.89 (0.06)	99.96 (0.03)
Asdex	99.10 (0.09)	99.36 (0.14)
BullfroHg	98.88 (0.64)	99.38 (0.48)
Durr 7800/7801	98.06 (1.08)	97.66 (0.35)
ECO II	98.17 (0.43)	97.51 (0.74)
Hg5	99.36 (0.15)	99.28 (0.10)
Hg10	99.99 (0.00)	Not tested
MRU	99.96 (0.03)	99.95 (0.04)
MSS 2000	99.66 (0.30)	98.94 (0.06)
Rasch 890-4000	99.93 (0.03)	99.90 (0.03)
RME 2000	99.67 (0.13)	99.66 (0.24)

* See Table 1 for manufacturers.
† SD: Standard deviation.

The results show statistical differences between the empty MSS 2000 amalgam separator and the full MSS 2000 amalgam separator ($P = .015$). For each of the other amalgam separators, there were no statistical differences between the empty separator and the full separator.

Total mercury concentration in effluent. Because of the large range of values for each separator, we did not calculate mean values or standard deviations for total mercury concentration in the effluent from the laboratory testing. Instead, Table 3 provides the range of total mercury concentrations in the effluent for empty amalgam separator tests, and Table 4 (page 583) provides the range of values for full separator tests.

Total dissolved mercury in effluent. Tables 3 and 4 show the total dissolved mercury concentrations in the effluent for empty separator testing and for full separator testing, respectively. Again, because of the large range of values for each amalgam separator, we report the ranges instead of mean values and standard deviations. The filter tap water (that is, the control) was below the 0.2-ppb detection limit.

DISCUSSION

In our laboratory evaluation of the amalgam removal efficiency of amalgam separators, we used the test method specified in ISO 11143. This test method and the particle-size distribution of the amalgam sample specified in the ISO standard were developed after considerable discussion among countries involved in the development of ISO standards. The particle-size distribution requirement was chosen to reflect amalgam particles generated during dental office procedures.[8,9]

Our test results show that the amalgam sepa-

TABLE 3

TOTAL MERCURY CONCENTRATION AND DISSOLVED MERCURY CONCENTRATION IN EFFLUENT FROM EMPTY AMALGAM SEPARATOR TESTING.

AMALGAM SEPARATOR*	RANGE OF TOTAL MERCURY CONCENTRATION FROM AMALGAM IN EFFLUENT (ppb†)	RANGE OF TOTAL DISSOLVED MERCURY CONCENTRATION FROM AMALGAM IN EFFLUENT (ppb)
A1000	30,200-34,899	20-89
Amalgam Collector	1,180-3,350	53-285
Asdex	9,930-15,750	4-16
BullfroHg	5,850-16,270	53-285
Durr 7800/7801	970-4,070	9-19
ECO II	16,310-26,340	14-33
Hg5	6,430-9,600	18-32
Hg10	20-100	1-5
MRU	200-570	47-150
MSS 2000	730-4,040	15-188
Rasch 890-4000	600-1,250	3-19
RME 2000	1,530-3,430	2-5

* See Table 1 for manufacturers.
† ppb: Parts per billion.

rators removed 96.09 percent or more of the amalgam particles that simulate particle sizes generated during dental procedures. The ISO amalgam sample contains particles as large as 3.15 mm. Particles of that size, along with those as small as 0.7 mm, would be retained by chairside traps, since most of these traps have nominal pore sizes of 0.7 mm. If vacuum filter traps were used in the dental office suction line, amalgam particles as small as 0.4 mm would be removed from dental office wastewater. Thus, these amalgam particles would be removed before they ever reached an amalgam separator.

Nevertheless, our results show that amalgam separators can remove a considerable amount of amalgam particles. At present, very limited information is available in regard to the amalgam removal efficiency of separators in actual dental office settings. A Danish study reported that the mean amount of mercury from amalgam found in wastewater from dental offices without amalgam separators was about 6.9 times that from dental offices with amalgam separators.[10] However, this study did not report the amalgam removal efficiency of the separators. An evaluation of point-of-discharge (that is, into-the-sewer) treatment technologies used by commercially available amalgam separators also did not address amalgam removal efficiency.[11]

Amalgam removal technologies. Several types of removal technologies are used in the design of amalgam separators. Our results show little difference among the separators in regard to efficiency. Sedimentation technology is used in the majority of amalgam separators, sometimes in conjunction with filtration and ion exchange. Because of its high specific gravity (about 10), amalgam particles settle quite readily from suspension in water. A study of the settling of amalgam in dental office wastewater samples reported that, in most samples, more than 90 percent of amalgam particles in a water column settled from suspension within about two hours.[12] Thus, sedimentation may play an important role in enabling amalgam separators that use this technology to achieve high removal efficiencies.

Filtration also is used, either by itself or in conjunction with sedimentation, as another removal technology. Our results show that an amalgam separator based solely on filtration results in amalgam removal efficiency similar to that of amalgam separators that use sedimentation in conjunction with other removal technologies. Our results also show that the efficiency of the amalgam separator that used centrifugal technology was statistically different from that of all but two amalgam separators that used sedimentation technology. However, although our results show statistical differences between amalgam separators, the differences are not likely to be practically significant because each of the separators tested had an amalgam removal efficiency of 96.09 percent or greater.

Total mercury concentration. We evaluated the total mercury concentration in effluent from

the amalgam separators because regulatory agencies almost always use this concentration to define wastewater discharge limits or water quality limits. Our results show that the total mercury concentrations in the effluent were in the parts-per-billion range and varied widely for each amalgam separator tested. This could be due to the variation in the number of small amalgam particles in each of the ISO samples used. We should note that although the results cover a wide range, they may suggest that the total mercury concentrations in the effluent from some amalgam separators are higher than those from other separators. However, our data in regard to total mercury concentration in the effluent are too limited to allow us to make such a conclusion.

TABLE 4

TOTAL MERCURY CONCENTRATION AND DISSOLVED MERCURY CONCENTRATION IN EFFLUENT FROM FULL AMALGAM SEPARATOR TESTING.

AMALGAM SEPARATOR*	RANGE OF TOTAL MERCURY CONCENTRATION FROM AMALGAM IN EFFLUENT (ppb†)	RANGE OF TOTAL DISSOLVED MERCURY CONCENTRATION FROM AMALGAM IN EFFLUENT (ppb)
A1000	27,830-34,420	69-113
Amalgam Collector	690-1,710	58-231
Asdex	9,480-17,950	1,017-7,569
BullfroHg	3,500-7,470	835-3199
Durr 7800/ 7801	2,380-3,490	14-40
ECO II	23,260-39,690	40-157
Hg5	9,140-15,150	106-5,915
Hg10	Not tested	Not tested
MRU	203-700	2-12
MSS 2000	5,410-6,170	6-13
Rasch 890-4000	1,000-1,760	20-51
RME 2000	770-4,450	8-95

* See Table 1 for manufacturers.
† ppb: Parts per billion.

Previous studies have reported that effluent from laboratory testing of amalgam separators contained amalgam particles 100 µm or smaller.[13] Variations in the number of amalgam particles that were 100 µm or smaller in the ISO amalgam samples could have caused the wide ranges that we observed in the total mercury concentration values. Additional research to determine the total mercury concentration in effluent using amalgam samples containing only particles 100 µm and smaller would provide further information to address this issue.

Total dissolved mercury concentration. We also evaluated the total dissolved mercury concentration in effluent from the amalgam separators. The EPA considers all mercury species that pass through 0.45-µm filters to be dissolved mercury. Thus, colloidal amalgam particles smaller than 0.45 µm and ionic mercury in solution are both included in the total dissolved mercury determination.

As is the case for total mercury concentration in effluent, we observed wide ranges in values for total dissolved mercury for each amalgam separator. However, these values were higher than the value of mercury in filtered tap water. Variations in the number of amalgam particles smaller than 0.45 µm in the samples tested could explain the wide-ranging values, since the ISO standard does not specify the number of amalgam particles that can be smaller than 0.45 µm. To evaluate the efficiency of amalgam separators in removing dissolved mercury, samples containing defined numbers of colloidal amalgam particles and a defined amount of ionic mercury in solution would be needed.

The results of our laboratory evaluation show that amalgam separators removed more than 96 percent of the amalgam particles in ISO-defined test samples. However, the effluent from the amalgam separators, when tested according to the EPA method (which includes acid digestion to change amalgam to cationic mercury for chemical analysis), contained total mercury concentrations in the parts-per-billion range. Regulatory agencies typically use the EPA test method to measure

total mercury in wastewater. Because the effluent limits for mercury in some areas of the country are lower than the parts-per-billion range and approach the parts-per-trillion range, our test results show that the effluent from amalgam separators would not meet these limits for mercury.

CONCLUSION

In this laboratory evaluation of 12 commercially available amalgam separators, we found that all had amalgam removal efficiencies of 96.09 percent or higher, which surpasses the 95-percent requirement specified in the ISO 11143 standard for amalgam separators. The statistical differences in efficiency between separators probably are not practically significant. The total mercury concentrations in the effluent from laboratory testing of the amalgam separators were in the parts-per-billion range and varied widely for each separator, as did the concentrations of total dissolved mercury in the effluent. Additional research is needed to develop test methods for evaluating the efficiency of amalgam separators in removing small amalgam particles, colloidal amalgam particles and ionic mercury in solution. ■

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See accompanying sidebar and table.

Amalgam in dental office wastewater
Addressing the issue

In recent years, the U.S. Environmental Protection Agency, or EPA, has substantially lowered the maximum level of mercury allowed in rivers, streams and other bodies of water. As a result, municipal sewage treatment plants now are required to substantially decrease the amount of mercury in their treated wastewater discharge.

Source control, which is the elimination of mercury from the wastewater entering sewage treatment plants, is the method being promoted by the EPA and the sewage treatment agencies for the reduction of mercury discharged into the surrounding aquatic and natural environment. In certain parts of the country, most notably states in New England, in the Great Lakes region and on the West Coast, dental offices are being asked to practice source reduction to decrease the amount of amalgam discharged into wastewater. Source reduction can vary from best management practices, including the proper disposal of chairside traps and vacuum filter traps, to the voluntary installation of amalgam separators.

Recognizing the need for information about amalgam separators, the Association conducted an evaluation of amalgam separators in regard to their amalgam removal efficiency in a laboratory setting, according to International Organization for Standardization Standard 11143 for Amalgam Separators.[1] The evaluation also measured the total mercury concentrations in effluent from the amalgam separators during laboratory testing. Although each amalgam separator tested exceeded the international standard of 95 percent amalgam removal efficiency, the installation of amalgam separators that meet this standard still may not satisfy the increasingly stringent regulatory requirements that have been established in some locations.

The installation of amalgam separators that meet the international standard of 95 percent amalgam removal efficiency may not satisfy the increasingly stringent regulatory requirements that have been established in some locations.

In addition to the laboratory evaluation results presented in the preceding article, more detailed product information about commercially available amalgam separators is provided in the following table. When making a decision to install an amalgam separator, dentists should consider the following: one's professional need to meet established regulatory requirements for mercury discharge; the dental office's plumbing configuration; the physical space required for installation; the maintenance that will require attention by dental office personnel; and the proper disposal of collected amalgam waste.

Cost considerations will include the cost of the amalgam separator, the installation expense, the cost of replacement components and disposal costs. The following table provides information to assist dentists in regard to these considerations. The Association does not endorse the use of amalgam separators or any of these products, and provides this information solely for use by dentists who have an interest in amalgam separators.

The Association continues to actively address the issue of amalgam in dental office wastewater through the implementation of an action plan, which was approved by the ADA House of Delegates in 2001. This action plan includes further evaluation of amalgam reduction technologies and providing assistance to state and local dental societies in their response to amalgam wastewater issues in their localities. Dentists facing amalgam wastewater issues are urged to contact their state and local dental societies for additional information. ■

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TABLE

CHARACTERISTICS OF AMALGAM SEPARATORS.

BRAND NAME AND MANUFACTURER	TECHNOLOGY	MANUFACTURER'S INFORMATION						
		Description	Claims	Physical Dimensions (Inches)*	Installation	Maintenance	Disposal	Cost†
A1000 Air Techniques Inc., 70 Cantiague Rock Road, Hicksville, N.Y. 11801; 1-800-AIR-TECH	Sedimentation	The unit uses a sedimentation process in which high-density particles (amalgam) fall from suspension in the wastewater stream and are trapped in the collection container. An optional gas/liquid/solid separator is available for use with the unit.	> 95% amalgam removal; ISO‡ 11143 certificate	L: 10.5 W: 6.25 H: 7.5	The unit is installed between the dental suction system/collection tank and the building sewer drain. The amalgam collection container and separation tank must be located so that the system will drain by gravity.	Amalgam collection containers must be replaced when one pound of amalgam has been collected, or every six months in a typical three-user practice. The system must be cleaned daily with a nonfoaming cleaner.	The dental office should contact a hazardous materials handler for disposal/recycling.	Suggested retail price: $750/unit; replacement costs: $500/kit; optional separator/collector tank: $1,695
Amalgam Collector R&D Services, 8120 Green Lake Drive N., Seattle, Wash. 98103; 1-206-525-4995	Sedimentation	The unit, made of polyvinyl chloride pipe, contains a mesh baffle and can be used as a chairside or central unit. The wastewater is allowed to settle overnight or over the weekend. A tube is lowered into the supernatant and a valve is opened to allow the suction to draw off the liquid down to a depth of two inches. When the unit is filled with sediment to the predetermined level, which is half-full, all the liquid is drawn off. The unit is removed for disposal and a new replacement unit is installed.	> 90% amalgam removal; King County (Wash.) Industrial Waste Program approved	H: 12-18 D: 6	The unit can be installed chairside or at a central location as an interruption in the vacuum system.	Periodic (could be daily) manual operation to suction off the collected liquid is needed. In an average office (four chairs), the unit needs to be replaced in about nine to 12 months.	The dental office is responsible for disposal of the collected amalgam waste.	Suggested retail price: $350/unit; replacement costs: $350/unit
Asdex Avprox Inc., 2201 Fourth St. N., Suite C, St. Petersburg, Fla. 33704, 1-800-300-1249	Filtration	The unit contains a disposable canister with locking end-cap fittings. The filter in the canister could remove particles as small as 10 to 15 micrometers. Life of the canister is estimated to be four to six weeks.	97.5% amalgam removal; ISO 11143 certificate; King County (Wash.) Industrial Waste Program approved	H: 9-10 D: 3	The unit can be installed either chairside or at a central location. The manufacturer recommends chairside installation to extend the life of the filter.	Canisters must be replaced every four to six weeks, or when the vacuum level begins to fall.	The dental office is responsible for disposing of used canisters.	Suggested retail price: $215/unit; replacement costs: $35/canister

TABLE

CHARACTERISTICS OF AMALGAM SEPARATORS (CONTINUED).

BRAND NAME AND MANUFACTURER	TECHNOLOGY	MANUFACTURER'S INFORMATION						
		Description	Claims	Physical Dimensions (Inches)*	Installation	Maintenance	Disposal	Cost†
BullfroHg DRNA Dental Recycling North America Inc., P.O. Box 1069, Hackensack, N.J. 07601; 1-800-360-1001	Sedimentation	The unit is a combined solid and air/water separator. Three-phase flow (air/water/solids) enters the unit from the dental office vacuum line. The entrained solids and liquids are retained in the unit while air flows out to the system vacuum pump. At the end of the day, a timer activates a pump to discharge the wastewater from the unit. Solid amalgam particles remain trapped within the unit.	> 95% amalgam removal; ISO 11143 certificate; King County (Wash.) Industrial Waste Program approved	H: 20.5 D: 8.5	The unit is designed to be installed on the suction side of a dental vacuum pump, preferably close to the pump. It is designed to work with either wet or dry vacuum systems.	Amalgam separators must be replaced annually.	The company arranges for amalgam waste recycling. The lease cost includes recycling.	Suggested retail price: Lease $100/month; replacement costs: included in the lease
Durr System 7800/7801 Air Techniques Inc.	Centrifugation	The unit uses a centrifuge that switches on when sufficient liquid is present. A pump conveys the wastewater liquid to the centrifuge. A water ring, which is rotated by inertia, rinses the separator particles out of the centrifuge and down into the cassette. The unit has a coarse-particle filter, which catches all the large particles before the centrifuge. It also contains a recycling cassette, which is monitored automatically for the fill level. A remote indicator signals both optically and acoustically the need to change the cassette, typically once a year.	> 96% amalgam removal; ISO 11143 certificate	H: 16.5 W: 11.5 L: 13	For central installation, the manufacturer recommends mounting the unit on an angle frame fixed to the wall or floor.	The cassette needs to be replaced when the indicator signals go on.	The company arranges for recycling of amalgam in the cassette.	Suggested retail price: $4,000; replacement costs: $95
ECO II (Economy System Type II) Metasys, 5001 S.W. 74th Court, Suite 206, Miami, Fla. 33155; 1-305-807-6303	Sedimentation	The unit is an amalgam separator and collection tank in one. The water–air–amalgam mixture enters the unit through the inlet in the lid at the top. The amalgam particles are separated by sedimentation. Very fine particles are separated out in a second sedimentation step. The effluent wastewater leaves the unit via the opening on the underside of the unit. The entire Economy System Type II needs to be replaced when the unit is full of amalgam sludge. Maximum flow rate is 3 liters/minute.	> 95% amalgam removal; ISO 11143 certificate; King County (Wash.) Industrial Waste Program approved	H: 13.8 W: 8.7 L: 8.7	The unit can be connected chairside or at a central location. It can be used for wet or dry vacuum systems. For a wet-vacuum system, the unit is installed in the suction line upstream of the vacuum pump. For a dry-vacuum system, the unit is installed after air/water separation in the waste line.	Amalgam separators must be replaced annually.	The company arranges for recycling of the amalgam waste collected in the unit.	Suggested retail price: Lease $29/month; replacement costs: included in the lease

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TABLE

CHARACTERISTICS OF AMALGAM SEPARATORS (CONTINUED).

BRAND NAME AND MANUFACTURER	TECHNOLOGY	MANUFACTURER'S INFORMATION						
		Description	Claims	Physical Dimensions (Inches)*	Installation	Maintenance	Disposal	Cost†
Hg5 SolmeteX Inc., 50 Bearfoot Road, Suite 2, Northborough, Mass. 01532; 1-508-393-5115	Sedimentation/ filtration/ ion exchange	The system consists of sedimentation, mechanical filtration and a chelating unit containing a resin to remove soluble mercury. Filtration and chelation occur in a replaceable filter-resin cartridge.	> 98% amalgam removal; King County (Wash.) Industrial Waste Program approved	H: 29 W: 13 L: 10	The unit must be installed in an upright vertical position in the existing piping between the last treatment room and the inlet to the vacuum pump. According to the manufacturer, best performance of the unit is achieved when it is installed such that the inlet is below the operatories and the vacuum pump is below the outlet.	The filter-resin cartridge should be replaced every one to six months, depending on the number of dentists and the type of practice.	The dental office is responsible for disposal of the filter cartridge.	Suggested retail price: $500; replacement costs: $75/filter resin cartridge
Hg10 SolmeteX Inc.	Sedimentation/ filtration/ ion exchange	The system has a collection vessel (25-gallon) and a process tank, which includes level control, process pump and access port. When the level reaches a set point, the process pump pumps the wastewater through a filtration system to remove particulates and a proprietary ion-exchange resin to remove soluble mercury.	Mercury in the effluent is generally < 0.2 parts per billion; King County (Wash.) Industrial Waste Program approved	H: 48 L: 48 W: 24	The wastewater from the vacuum system is retained in the collection vessel. If an air-water separator is used, then use gravity flow into the collection vessel. The unit must be installed with clear access to the filter cartridge and tablet feeder for weekly maintenance.	Oxidizer tablets should be added weekly. The filter cartridge and resin cartridge should be replaced quarterly.	The dental office is responsible for disposal of the used filter cartridge and resin cartridge, as well as the amalgam waste collected in the collection vessel.	Suggested retail price: $6,000; replacement costs: filter cartridge $150, resin cartridge $275
MRU (The Mercury Recovery Unit) DRNA Dental Recycling North America Inc.	Sedimentation/ filtration/ion exchange	The unit combines gravity settling to capture amalgam particulate and adsorbent to remove dissolved mercury.	> 95% amalgam removal; King County (Wash.) Industrial Waste Program approved	H: 24 L: 24 W:12	The unit must be installed on the suction side of the vacuum pump, preferably close to the pump. It is designed to work with wet or dry vacuum systems. In a dry-vacuum system, the unit should be installed upstream of the air/water separator.	The separator, filter and absorbent column should be recycled every six to 12 months.	The company arranges for amalgam waste recycling. The lease cost includes recycling.	Suggested retail price: Lease $150/ month; replacement costs: included in the lease

TABLE

CHARACTERISTICS OF AMALGAM SEPARATORS (CONTINUED).

BRAND NAME AND MANUFACTURER	TECHNOLOGY	MANUFACTURER'S INFORMATION						
		Description	Claims	Physical Dimensions (Inches)*	Installation	Maintenance	Disposal	Cost†
MSS 2000 Maximum Separation Systems Inc., 301-1779 Sean Heights, Victoria, B.C., V8M 1X6 Canada; 1-800-799-7147 or 1-250-652-5279	Sedimentation/ filtration	The unit consists of three components: the surge tank (volume = 27 liters), the settle tank (volume = 6 L) and the control/indicator panel. The surge tank ensures that the settle tank receives a regulated flow of fluid. The settle tank takes the wastewater from the surge tank and directs the fluid through a series of chambers and filters. The surge tank portion of the control panel is designed to identify the level that the surge tank has reached during the day's operation.	98.8% of amalgam removal; ISO 11143 certificate; King County (Wash.) Industrial Waste Program approved; Environmental Choice Program (Canada) certificate	H: 28 L: 18 W: 15	The unit is to be installed upstream of existing dental office vacuum systems. The unit could be mounted on the wall or on the floor. The settle tanks should be near the level of the drain line to the vacuum pump.	One settle tank lasts for approximately one year.	The company offers on-site waste services through Safety-Kleen Corp. (Columbia, S.C.).	Suggested retail price: $3,000; replacement costs: $296/ settle tank
Rasch 890-4000 AB Dental Trends Inc., 211 Grover St., Lynden, Wash. 98264; 1-360-354-4722	Sedimentation/ filtration/ion exchange	The unit consists of four primary components: a buffer tank, which acts as an air/water separator; an amalgam collection canister; a racking system designed to be wall- or floor-mounted and provides support to both the air/water separator and the amalgam collection canister; and a scrubber kit. The total flow should not exceed 4 L/ minute.	> 95% amalgam removal; ISO 11143 certificate	H: 28 L: 13 W: 10	The unit could be mounted on a wall or floor that will support 60 pounds. The unit should be positioned for gravity fluid flow from the wet-vacuum pump through the unit to the sewer. The outflow from the wet-vacuum pump is to be connected to one of the inlets on top of the buffer tank.	The amalgam collection canister needs replacement approximately every 18 months per chair.	The company arranges for recycling of the amalgam-full canister.	Suggested retail price: $1,650; replacement costs: $750/ canister
RME 2000 Rebec, 18921 Dellwood Drive, Edmonds, Wash. 98026; 1-800-569-1088	Sedimentation	The unit has no electronic or moving parts. One unit will accommodate up to six dental units annually.	96.9% amalgam removal; ISO 11143 certificate; King County (Wash.) Industrial Waste Program approved	H: 24 L: 20 W: 7.5	Preferably, the unit is to be installed close to the vacuum pump. It could be adapted to the existing vacuum line with two simple connections.	Annual recycling should be scheduled.	The dealer handles recycling of the amalgam waste.	Suggested retail price: $1,895; replacement costs: $395/ settle tank

* L: Length. W: Width. H: Height. D: Diameter.
† Information accurate as of January 2002.
‡ ISO: International Organization for Standardization.